TECHNO Quest 1

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An Eaglemoss Publication

TECHNO Quest 1

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Acknowledgements The Space Food featured in Dairy Machines is available from Buxton Foods tel: 0171-637-5505. For more information about the Magellan GPS featured in Techno Talk contact Next Destination tel: 01722-410800

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Editorial and distribution offices: Eaglemoss Publications Ltd, 7 Cromwell Rd, London SW7 2HR
Editor: Jenny Mohammadi Art Editor: Patsy Merrick Production Controller: Priti Kothary

Colour origination by Colourscan, Singapore Printed in Great Britain by Cooper Clegg Ltd

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TECHNO Quest

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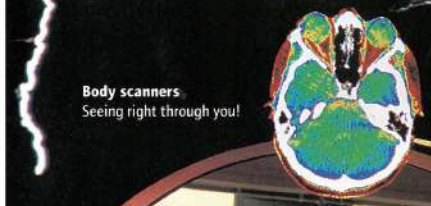
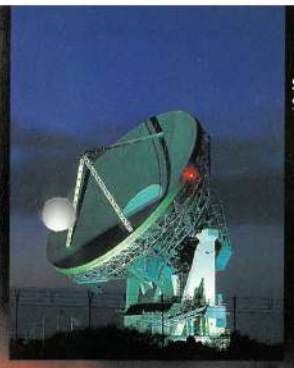


Body scanners
Seeing right through you!

SEE ALSO

SEE ALSO suggests some related entries you may want to read about.

Future topics include:
Acceleration
Air bags
Ballistics
Bioluminescence
Body scanners
Nuclear energy
Solar system
Sonar
Space technology
Virtual reality
Weather



Satellite communication
Signals across the universe

Bioluminescence
Glowing in the dark

WORKSHOP

Wallace's workshop is where our intrepid inventor puts his ideas to the test and suggests some simple experiments for you to try at home.

DID YOU KNOW?

Did you know? No.... Well you will when you see this sign and check out the fantastic facts that will stun your friends.

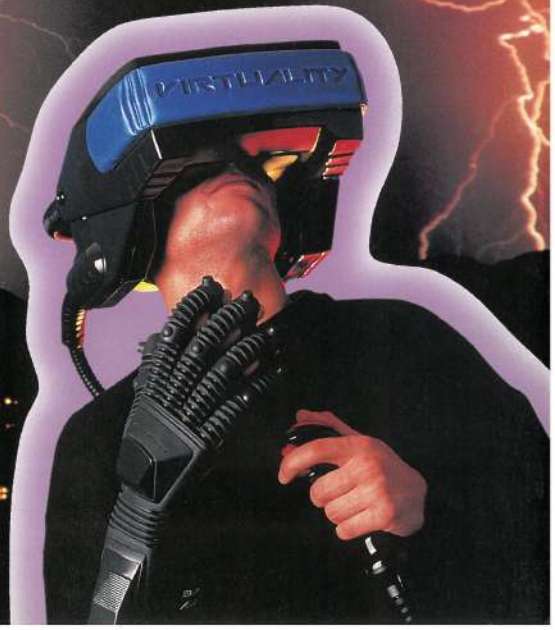
The Bare Bones

The Bare Bones – where basic principles, theories and laws of science and technology are explained in simple terms.

TECHNO Talk

Fun-filled pages featuring:

- Up-to-the-minute facts and figures
- Stop press news
- What's on the techno grapevine
- Brain teasers and quizzes to give you a cerebral work out!

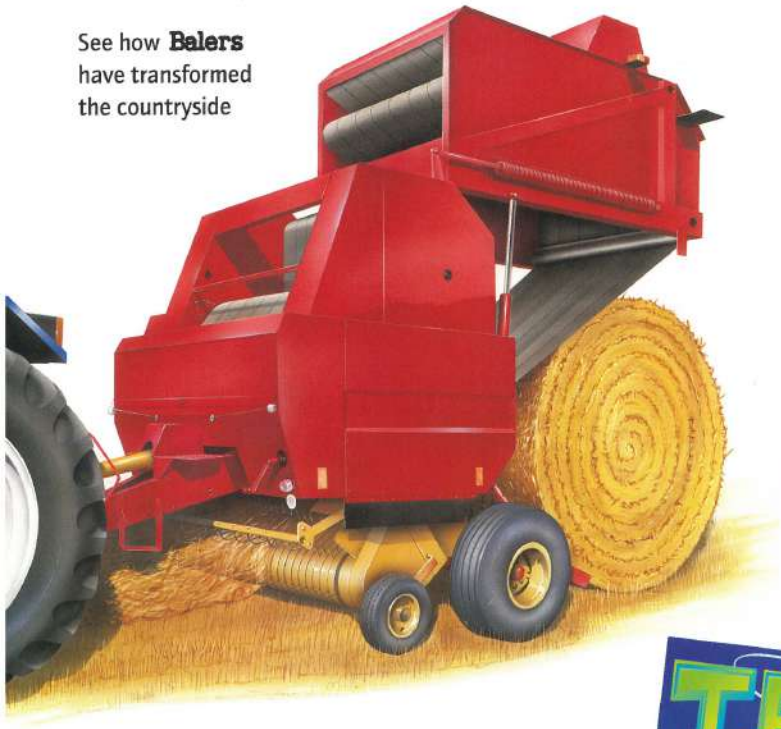


Virtual reality
Out of this world?

COMING IN PART 2

More entries to file under A, B and C

See how **Balers** have transformed the countryside



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Aardman Animations

Wallace and Gromit are the stars of Aardman Animations, a British film company that grew out of two schoolboys' interest in making animated films at home. Peter Lord and David Sproxton were the schoolboys, and their big break came in 1972 when a BBC television producer invited the pair to contribute to his children's television programme.

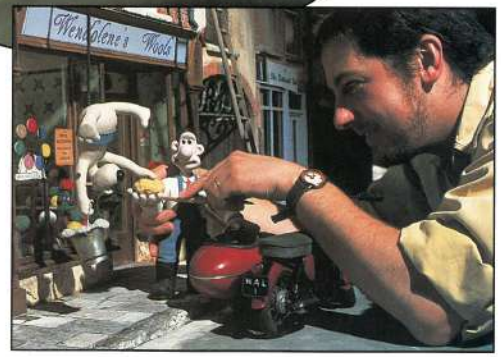
THE BIG TIME

The name Aardman comes from the character in the first film the two made for the BBC. Aardman Animations, the company they formed, has now grown into a world-famous studio, producing a huge range of innovative animated films and television commercials.

◄ In this scene from *A Close Shave*, Wallace and Gromit set off by motorbike and sidecar for another day cleaning windows.

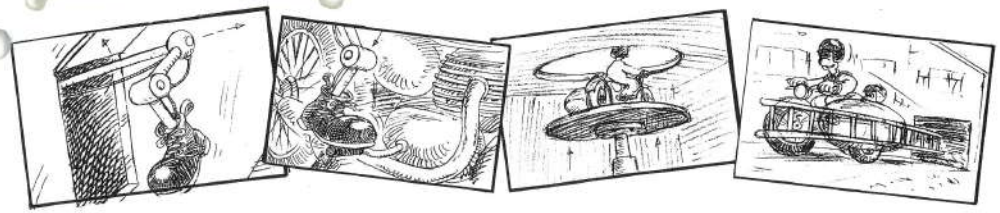
The Bare Bones

Making animated films with small movable models involves a special technique known as stop-frame animation. Each second of action consists of 24 separate frames, recorded one by one on cine film and video, with tiny changes being made to the characters' positions, the props and even to the sets between individual frames. On a good day, the production team may complete no more than two or three seconds of film.



► After each frame is shot, the animator steps in to move the action forward a fraction, ready for the next frame. The Plasticine figures are only a little bigger than a man's hand and are minutely detailed.

▼ Story-boards are used to plan every sequence of the film precisely.



AARD WORK

Aardman Animation's first major production was the ever-popular children's series *The Amazing Adventures of Morph*. Through the 1980s they continued to develop the art of animating puppets to match real-life conversations. They also produced television commercials, created rock videos and helped writer/director Nick Park to complete his first Wallace and Gromit film, *A Grand Day Out*. Released in 1989, it won a British Academy award in 1990 for Best Short Animated Film, and was then nominated for an Oscar® the following year.

◁ Characters in the short animated film *Creature Comforts* were created by Nick Park and were the inspiration for a highly original series of TV advertisements for the electricity business.

WENDOLENE RAMSBOTTOM

Wallace and Gromit's next big adventure, *The Wrong Trousers*, took 13 months and £650,000 to make, with a full-time crew of 10 people working on it. It won the 1993 Oscar® for Best Animated Short Film and turned the highly inventive Wallace and his canny canine friend – not to mention a small criminally inclined penguin – into international superstars.

Aardman's third Wallace and Gromit thriller, *A Close Shave*, introduces some new characters, including Wallace's first love interest Wendolene Ramsbottom, and the evil Preston. The film also shows off Wallace's famed powers of invention to even better effect than ever before. It was released for Christmas 1995, and brought Park and Aardman their second Oscar® some three months later.

△ Nick Park was born in 1958, and first became interested in animation at school. He went on to study at the National Film and Television School, where he started work on *A Grand Day Out*, and joined Aardman Animations in 1985. Here Nick is using a stopwatch to time the story-board action.

THE TECHNO TROUSERS

FEATHERS McGRAW

◁ *The Wrong Trousers* features a host of stunning mechanical special effects and a cunningly disguised penguin who hijacks amateur inventor Wallace and his amazing techno trousers. It's up to Gromit to save the day.

SEE ALSO
Animation
Films and film-making

Abrasives

Abrasives are products that grind, scour and polish other materials, shaping or smoothing them by wearing away the surface. Some are natural; most are man-made.

You use abrasives every day, although you may not know it. Brushing your teeth? Filing your nails? Smoothing off a wooden model? Toothpaste, an emery board and a sheet of sandpaper are all abrasives, and they all work in the same way, by removing a little (or a lot) of the surface they're applied to and leaving it feeling smooth. And before you say it, brushing your teeth does not wear your teeth away. Toothpaste gets to work on the sticky film of bacteria (plaque) that coats unbrushed teeth.

Abrasives are also important in industry, where they shape wood and metal, sharpen tools, polish gemstones, clean grimy buildings and drill holes in rock.

Sand and many other natural minerals – quartz, emery and diamond, for example – are used as abrasives. There are also man-made abrasives, including glass and artificial diamonds.

Abrasives are used as loose particles – on their own, for grit-blasting a building, or in a liquid or paste form like your toothpaste or metal polish. They are stuck to a paper or cloth backing as well to make sheets or belts for use when sanding by hand or with power tools. Sand is not used any more to make what woodworkers still call sandpaper; instead, the abrasive coating is finely powdered glass – hence the term glasspaper.

Abrasive particles are bonded together so that they can be shaped into discs to make such things as grinding wheels. They are also stuck to drill bits and saw blades to improve their performance. The coarser and harder the abrasive is, the faster it cuts; the finer and softer, the better it polishes.

△ Waves grind rocks into pebbles and then into sand – by far the most plentiful abrasive material on Earth.

△ The grinding wheels that bored the Channel Tunnel are the biggest abrasive tools ever built.

The Mohs scale

diamond 10

metal file 8

glass 6

teeth 5

fingernail 3

▽ When magnified 1300 times, abrasive crystals in toothpaste look like small rocks.

toothpaste 2

△ **The Mohs scale** Abrasives are graded on a hardness scale from 1 to 10. The scale was devised in 1812 by Friedrich Mohs.

◁ Sand – blasted from a nozzle by compressed air– is an ideal abrasive for removing stains and atmospheric pollution from grimy buildings and machinery.

The Bare Bones

An abrasive has to be as hard as (or harder than) the material it is 'abrading'. The only thing that will scratch or abrade diamond – the hardest known substance – is another diamond.

SEE ALSO
Diamonds, Erosion, Minerals, Seashore

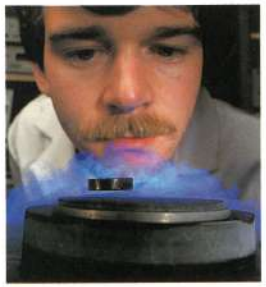
Absolute Zero

There's a limit to how cold things can get. Just how cold is it? The temperature scale (right) shows some natural sub-zero temperatures and some that scientists have created as they make things colder and colder.

Atomic standstill

Going down the temperature scale means decreasing the amount of heat around. Heat is a measurement of the movement of atoms, the basic particles of all matter. At normal temperatures, they move very fast and have lots of energy. As the temperature drops, they begin to slow down. You might think that it should be possible to reach a temperature where they don't move at all.

In 1851, the Scottish physicist William Thomson, who later became Lord Kelvin, calculated that this would be –273.15°C. He called it absolute zero. He also proved that, while scientists can get ever closer to absolute zero, they can never get all the way there. The laws of physics don't allow atoms to be completely motionless. It's like taking a lift down into the temperature basement but never quite reaching the bottom of the liftshaft.



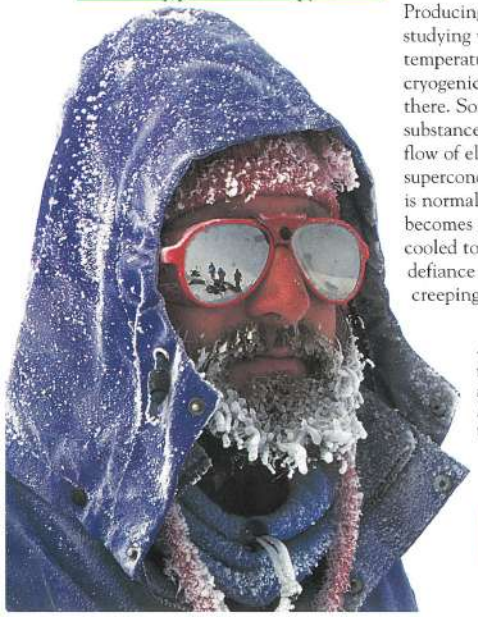
▽ Close to absolute zero, strange things happen. Here a metal disc hovers on the magnetic field around a piece of ceramic material super-cooled in liquid nitrogen.

Kelvin scale

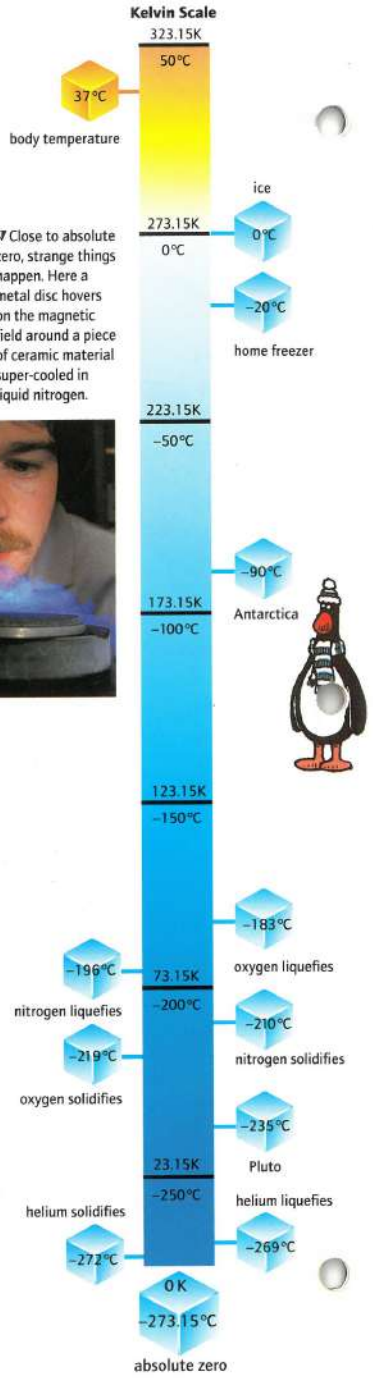
His theories led Thomson to propose a new temperature scale – the Kelvin scale – which is now widely used by scientists. It starts at absolute zero, and uses the same degree intervals as the Celsius (centigrade) scale. However, temperatures on the Kelvin scale are written without the degree symbol. So water freezes at 273.15K (0°C) and boils at 373.15K (100°C).

Strange behaviour

Producing very low temperatures and studying what happens down in the temperature basement is called cryogenics. Strange things happen there. Some metals and metallic substances lose all resistance to the flow of electricity and become superconductors. Helium gas, which is normally used to fill airships, becomes a super-fluid when it is cooled to below 2K, flowing uphill in defiance of gravity and literally creeping out of any open container.



◁ Antarctica holds the record for the world's lowest air temperature at almost 90°C below zero. Absolute zero is just over three times colder than this.



DID YOU KNOW?

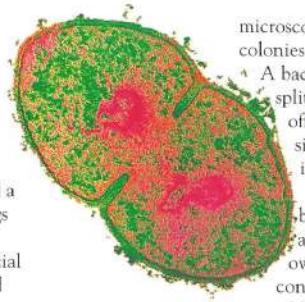
GETTING EVER CLOSER
In 1995 scientists got down to 170 billionths of a degree above absolute zero. A hundred years ago they had only just managed to liquefy nitrogen at 77K.

SEE ALSO
Cryogenics, Superconductors, Temperature

Bacteria

What are so tiny that they are invisible to the naked eye yet thrive *on* everything you see, touch and eat and *inside* all plants and animals? What are helpful to humans but can cause decay and disease? The answer is bacteria (one is called a bacterium) – also known as bugs and germs or microbes.

Bacteria are placed in a special kingdom of living things called Monerans. Their simple structure makes them neither quite plant nor animal. Nor are they to be confused with viruses, which also cause diseases but have a different structure and can't reproduce themselves.



◭ Hugely magnified, a bacterium is caught in the act of reproducing. The cell wall is growing across the middle to divide it into two new bacteria.

Fast breeders

Each bacterium is a single living unit – one cell. Most measure less than two-thousandths of a millimetre and you can only see them under a microscope or when they grow into colonies of many millions.

A bacterium reproduces mainly by splitting itself in two. The two offspring cells grow back to full size, then each splits into two in its turn – again and again.

A human generation, from birth to having children, is about 20 years. Left to its own devices under perfect conditions, a bacterium divides every 20 minutes – producing 72 generations in 24 hours.

Spreading bacteria

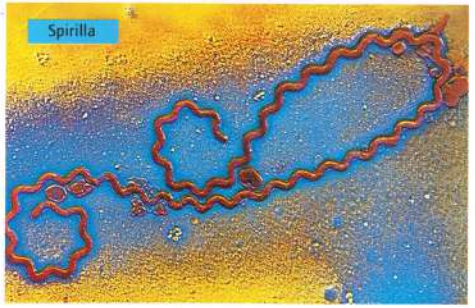
Bacteria largely rely on being carried around in water or air. They also hitch lifts on other agents, such as damp dishcloths and houseflies. You can spread bacteria by touching food with dirty hands.

▽ **Daily bug contacts**
During the day you come into contact with lots of different bacteria in all sorts of places. You rarely come to any harm because you can outwit most of them.

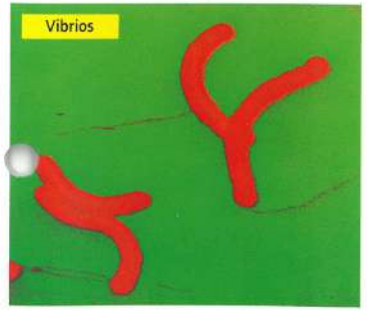
Whenever you wash your hands after going to the toilet, bacteria take a dive down the plug hole.

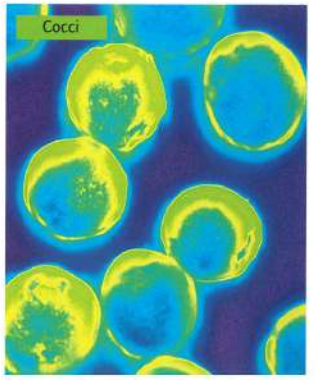
Bacteria rejoice at being launched by a sneeze – until they find themselves netted in a handkerchief.

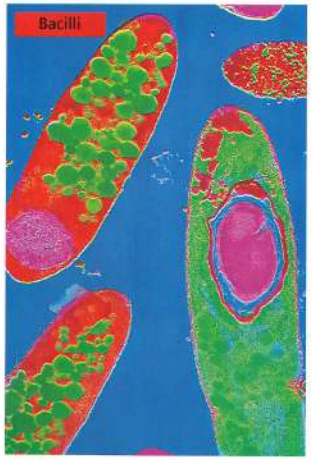
If bacteria were to build a 100,000-seater sports stadium, it could fit on a pinhead ●



Groups of bacteria
Bacteria are grouped into four basic shapes – spiral Spirilla, comma-like Vibrios, ball-shaped Cocci, rod-like Bacilli. The ones here are shown about 5000 times larger than life.







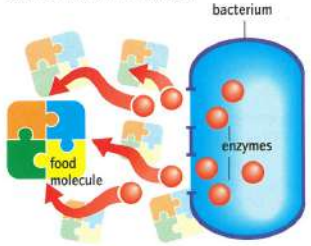
Unfussy eaters

Like all living things, bacteria need a constant supply of food for energy and growth. As well as food, some also need oxygen to survive; others can manage without.

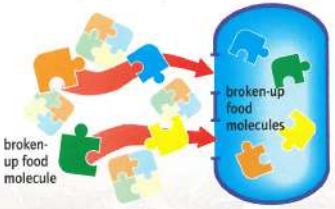
To bacteria, almost anything counts as food, from a juicy piece of meat to a dead leaf or pure yellow sulphur. They simply feed on the plant or animal material they find themselves sitting on – which is bad news when it's your supper too.

HOW BACTERIA FEED

A bacterium leaks digestive chemicals called enzymes into its surroundings.



The enzymes break down complex food molecules into simpler ones that are taken in through the bacterium's cell wall.



▲ In sewage treatment plants, bacteria help clean up the water by breaking down dangerous waste substances into harmless chemicals.

Putting bacteria to work

Bacteria's habit of releasing digestive enzymes is useful. The dirt gobblers in biological washing powders are harvested from bacteria grown especially for the purpose. Bacteria are also widely used as helpers in the brewing, dairy, plastics and pharmaceutical (drugs) industries.

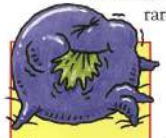
The good guys

Behind the scenes, many bacteria are working hard for your benefit. The next time you eat a yogurt or a cheese sandwich, for example, you might spare some thanks for the *Lactobacillus* bacteria that helped to produce it.

As far as humans are concerned, bacteria are generally most helpful as decomposers and recyclers. They can rot down any biodegradable materials – animal waste, dead organisms and things made from them, such as paper and leather – into a liquid that they take on board as food. In the process, they return valuable chemicals to the soil for re-use.

Special skills

Special bacteria on the roots of pea, bean and clover plants have a rare but useful talent for trapping the nitrogen in the air and soil. They convert it into fertilizer-like chemicals that enrich the soil and help plants grow.



When you see some cows grazing, think of the bacteria beavering away in their guts helping to digest the grass.

Plant eaters, like cows and rabbits, rely on huge colonies of bacteria in their guts to help digest cellulose in plant cell walls. You have a large population of friendly bacteria living in your gut too.

▼ The leaf litter in a beech wood is teeming with bacteria busily breaking down dead animals and plants and releasing important nutrients for re-use.

MAKING YOGURT

With the help of a few million million *Lactobacillus* bacteria you can make your own yogurt which you can sweeten with sugar, honey or fruit. For a creamier yogurt, add two tablespoons of milk powder to the milk.

INGREDIENTS

600ml (1 pint) milk
30ml (2 tbsp) live natural yogurt
saucepan
tablespoon and wooden spoon
thermos flask

METHOD

In a small saucepan, carefully heat the milk until small bubbles form on the top. Leave to cool to about hot bath temperature. Stir the natural yogurt into the warm milk. Pour into a clean thermos flask and leave overnight. By morning, the bacteria will have done their job, turning the milk mixture into yogurt. Transfer the yogurt to a clean container and put it in the fridge to stop the bacteria growing.

When placed in the fridge to chill out, bacteria hiding in fresh and cooked foods have to put plans for increasing their numbers on hold.

◀ Bacteria are the mainstays of some sea-bed communities. They convert the mineral-rich water into food, which feeds thriving populations of giant tube worms, crabs and mussels.

A single bacterium can produce over 1,000,000 offspring between breakfast and lunch.

Bad guys

Bacteria are often cursed for the damage and diseases they cause. You can blame bacteria, for example, when you need a filling at the dentist. Feeding on food between your teeth, bacteria produce acid that creates holes in your tooth enamel.

The only way to get rid of bacteria on your teeth is by brushing regularly.

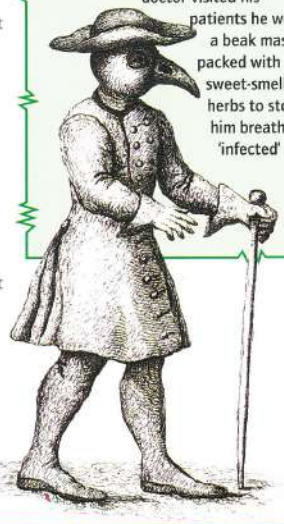
The dangerous bacteria are the ones that cause diseases. They are swallowed, breathed in or enter through cuts or insect bites. Fever, rashes, cramps, sickness and diarrhoea are signs that the bacteria are hurting or poisoning their host.

Bacterial diseases are a problem in countries where there is no fresh water supply, toilets, sewage disposal or refrigeration – hygiene facilities that many people take for granted.

DID YOU KNOW?

BEAK DOCTORS

Plague is caused by bacteria carried by rat fleas. But people didn't know this in the 17th century. When a doctor visited his patients he wore a beak mask packed with sweet-smelling herbs to stop him breathing 'infected' air.



Fighting back

Your skin is the first line of defence against bacterial invaders. Chemicals in sweat and tears are also toxic to bacteria. White blood cells and antibodies in the immune system dispose of any that slip through the net.

As a baby you can have injections against whooping cough or, if you go abroad, you can have them against diseases such as typhoid and yellow fever. These spur your immune system to make antibodies, in case you encounter any nasty bugs.

When you have an infection like a bad sore throat, a doctor can prescribe antibiotics, such as penicillin and streptomycin, to kill the bacteria responsible. Antiseptics and disinfectants work in similar ways outside your body.

Cooking at the right temperature for the correct length of time kills off harmful bacteria lurking in your food.

BRIGHT SPARKS

Antony van Leeuwenhoek, a Dutch draper in Delft, was the first person to see bacteria. In 1683, looking down a microscope that he had built in his spare time, he spied 'very many small animalcules' in a scraping from between his teeth. No one else reported seeing bacteria again for over 100 years.

Seeing is believing

The scum on polluted water is a chance for you to see the only other member of the Moneran kingdom, cyanobacteria. Better known as blue-green algae, cyanobacteria grow in vast numbers in warm weather. A green film spreads across the surface of ponds and lakes, poisoning the water and making them dangerous places for animals and people to swim.

◀ Sunny weather encourages the rampant growth of blue-green algae. They behave like plants and cook up their own food by trapping the power in sunlight with a green pigment called chlorophyll. They use it to turn water and carbon dioxide into energy-giving food.

SEE ALSO

Antibiotics, Antibodies, Antiseptics, Dairy machines, Food preserving, Genetic engineering, Nitrogen cycle, Photosynthesis, Recycling, Sewage treatment, Viruses

Cables

Cables are everywhere. Some pull things like lifts and cable cars up and down. Others keep things in place or hold them up. They anchor huge television masts and oil platforms, and support suspension bridges. More complex types of cables conduct electricity or carry various types of telecommunication signals around the house and across the world.

Inside electricity cables the conductors are a bundle of metal wires wrapped in plastic insulation.

Hauling and holding

The steel cables that haul things need to be flexible, so they are woven like a fibre rope from thin strands of wire. The individual wires are relatively weak, but the way the strands are twisted or interwoven gives the cable its strength. They come in a wide range of sizes, up to 125mm in diameter. In situations where ordinary steel could rust, coated or stainless steel wire is used instead.

Cables that anchor or support things don't have to bend, and are basically just a bundle of thick parallel wires. The largest cables of this type are the main support cables of suspension bridges. The two on the bridge linking Honshu and Shikoku in Japan are a massive 112cm in diameter – the biggest cables in the world.

The Golden Gate suspension bridge in San Francisco, USA.

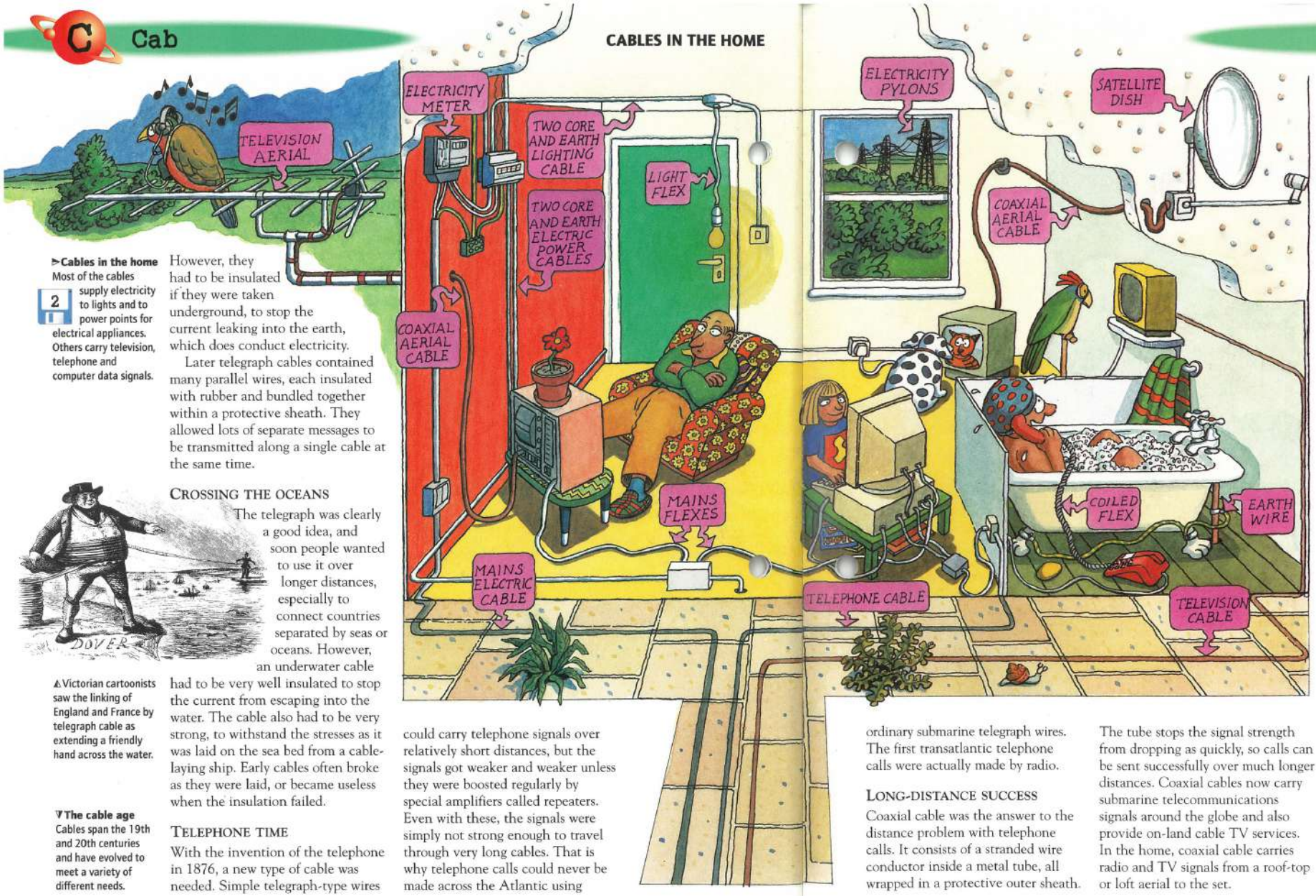
Sending signals down wires

In the early days of electrical experiments, scientists made solid metal wires to carry electricity round their circuits. Soon people began working on the idea of sending pulses of electric current down wires as a means of transmitting messages from one place to another. Within a few years the electric telegraph was born.

The first telegraph lines were bare copper wires strung between wooden poles. They didn't need insulating since air is itself an excellent insulator.

Cables can be strong steel ropes used to haul or hold things, or metal wires that conduct electricity or carry various types of telecommunication signals.

CABLES IN THE HOME



Cables in the home
Most of the cables supply electricity to lights and to power points for electrical appliances. Others carry television, telephone and computer data signals.

However, they had to be insulated if they were taken underground, to stop the current leaking into the earth, which does conduct electricity.

Later telegraph cables contained many parallel wires, each insulated with rubber and bundled together within a protective sheath. They allowed lots of separate messages to be transmitted along a single cable at the same time.

CROSSING THE OCEANS

Victorian cartoonists saw the linking of England and France by telegraph cable as extending a friendly hand across the water.

The telegraph was clearly a good idea, and soon people wanted to use it over longer distances, especially to connect countries separated by seas or oceans. However, an underwater cable had to be very well insulated to stop the current from escaping into the water. The cable also had to be very strong, to withstand the stresses as it was laid on the sea bed from a cable-laying ship. Early cables often broke as they were laid, or became useless when the insulation failed.

The cable age
Cables span the 19th and 20th centuries and have evolved to meet a variety of different needs.

TELEPHONE TIME

With the invention of the telephone in 1876, a new type of cable was needed. Simple telegraph-type wires could carry telephone signals over relatively short distances, but the signals got weaker and weaker unless they were boosted regularly by special amplifiers called repeaters. Even with these, the signals were simply not strong enough to travel through very long cables. That is why telephone calls could never be made across the Atlantic using ordinary submarine telegraph wires. The first transatlantic telephone calls were actually made by radio.

LONG-DISTANCE SUCCESS

Coaxial cable was the answer to the distance problem with telephone calls. It consists of a stranded wire conductor inside a metal tube, all wrapped in a protective outer sheath. The tube stops the signal strength from dropping as quickly, so calls can be sent successfully over much longer distances. Coaxial cables now carry submarine telecommunications signals around the globe and also provide on-land cable TV services. In the home, coaxial cable carries radio and TV signals from a roof-top or loft aerial to the set.

OPTICAL FIBRES

Cable technology moved on again when optical fibre cables were developed. Optical fibres are extremely fine threads of very pure glass, and signals are sent along them as coded bursts of light. A complete cable can contain a bundle of fibres, and is capable of carrying thousands of transmissions.

The cable needs no insulation since it is not carrying electric current. However it still needs a protective outer sheath, especially for underwater use where it has to resist attacks by fish and being hooked by ship's anchors. Each fibre has a colour-coded coating like the wires

DID YOU KNOW?

CABLE FIRSTS

The first telephone cable was laid across the Atlantic Ocean in 1956, and could carry 36 calls at the same time. By the 1980s more cables had been laid, increasing transatlantic capacity to some 13,000 calls.

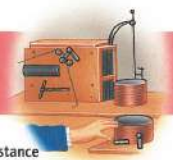
The first transatlantic optical fibre cable was laid in 1988, and can carry around 40,000 calls at once.

The world's longest optical fibre cable, running 27,000km from the UK to Japan, will be completed in the year 2000 at a cost of over £1 billion.

Coaxial cable

1816
First wire cable footbridge, Philadelphia, USA

1834
Stranded-wire cable used in mining industry in Germany



1844
First long-distance telegraph line, between Baltimore and Washington, USA

1850
First under-sea telegraph cable, between England and France

1866
First permanent transatlantic telegraph cable

1880s
Supply cables begin to distribute electricity from power stations

1930s
Coaxial cables developed to improve signal transmission

1970s
Optical fibre cables developed

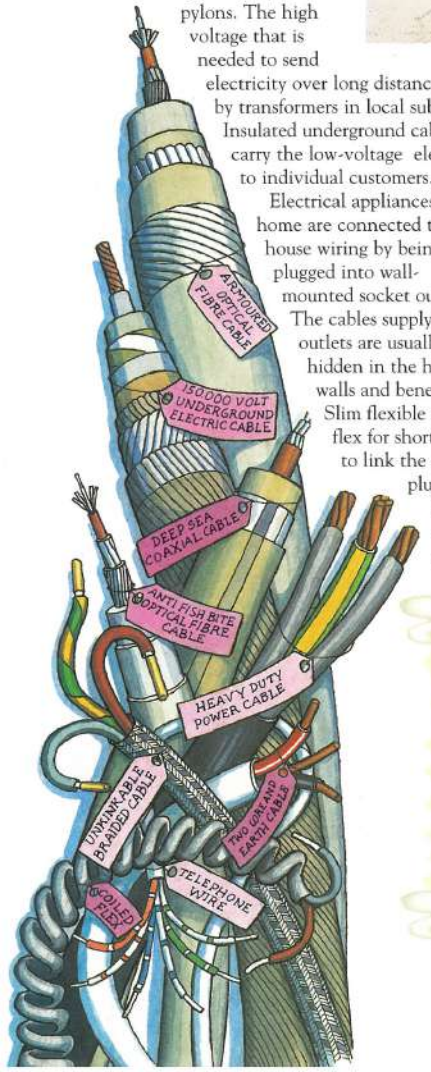
in electrical cables, so each end can be identified easily.

Apart from carrying telephone calls, optical fibre cables are now used to transmit large volumes of computer data over long distances at high speed, and also for the expanding cable TV networks.

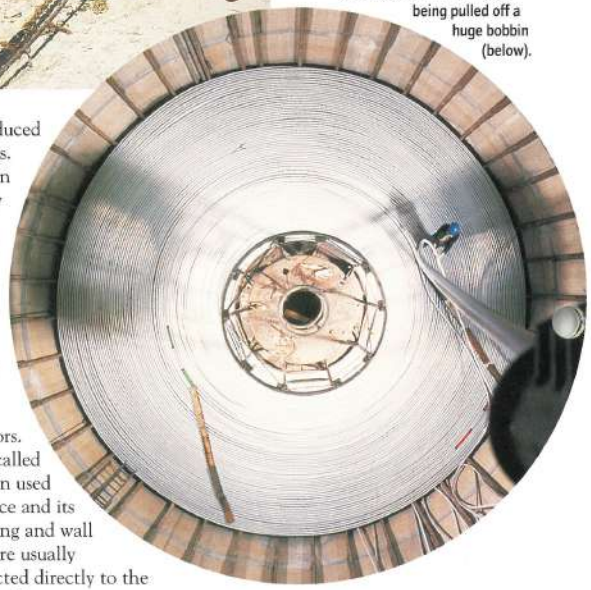
A SHOT OF JUICE

Cables of a different sort carry the mains electricity supply. The flow of electric current starts at the power station, and travels across country through a series of thick uninsulated cables that are supported by tall pylons. The high voltage that is needed to send electricity over long distances is reduced by transformers in local substations. Insulated underground cables then carry the low-voltage electricity to individual customers.

Electrical appliances in the home are connected to the house wiring by being plugged into wall-mounted socket outlets. The cables supplying the outlets are usually hidden in the house walls and beneath floors. Slim flexible cable (called flex for short) is then used to link the appliance and its plug. Ceiling and wall lights are usually connected directly to the mains cable.



Laying cables
Laying an underwater cable involves every level of technology, from hauling it ashore by hand (left) to digging a trench for it in the sea bed using a remote-controlled submersible (above). On a cable-laying ship, the cable is loaded into special cylindrical holds and is paid out like thread being pulled off a huge bobbin (below).



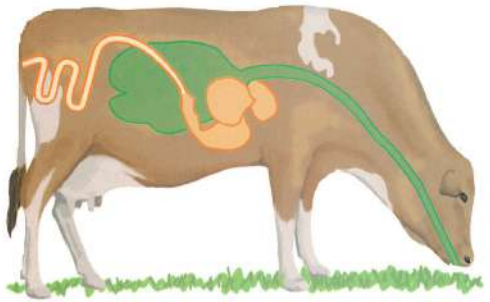
The Bare Bones

What's inside?
Electricity cables contain individual copper conductors. In the smallest cables, each conductor is a single wire but in larger cables, conductors consist of several thin strands. This makes them easier to bend as they snake their way around the house. Cables in the home are covered in tough plastic insulation. This insulates the conductors from each other so the current goes only to its destination, and also protects them from damage. Some cables contain a third conductor called the earth wire. This connects metal parts of electrical equipment in the home to earth – a sort of safety valve for any current that escapes.

SEE ALSO
Bridges, Cable cars, Cranes, Electricity, Lifts, Ropes, Telecommunications, Television

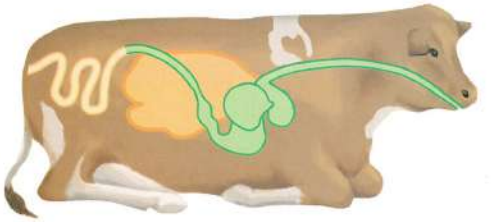
Dairy Machines

If you sat down for your breakfast cereal and poured on the milk, you'd be surprised if grass came out of the carton. Yet that's what milk is: processed grass. Cows – and many other animals such as goats, sheep, buffalo and reindeer – eat grass and turn it into milk. In some countries, people hand-milk their animals and drink the milk straight away. In most Western countries the cow is the favourite milk-producer, and the animal and its milk are part of a vast and highly mechanized dairy industry that makes butter, cheese and other products too. The whole process starts down on the farm.



◁ As the cow grazes, the grass goes into her large first stomach chamber (rumen). Natural bacteria help to soften the tough fibres and turn it into cud, ready to be brought up again for further chewing.

grass becomes cud cud is digested



◁ The well-chewed cud now passes into the other stomach chambers. Here acids break it down into a form that the cow can digest as food.

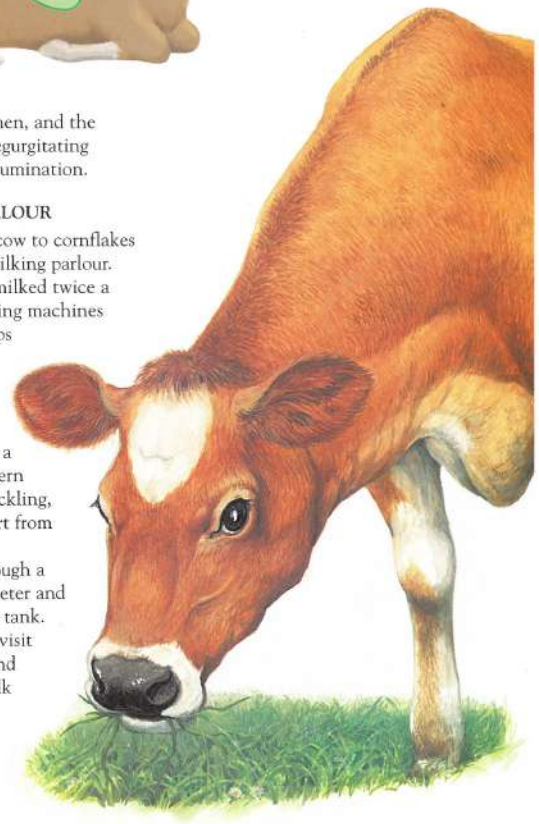
FEEDING TIME

Cows and other grass-eating animals have a four-part stomach to deal with their tough, fibrous diet. They chew the grass and swallow it as they graze. Later, they bring the partly chewed grass (called cud) back up into their mouths and chew it some more to make it easier to digest. The first stomach chamber the grass goes into is called the rumen, and the cow's chewing and regurgitating process is known as rumination.

THE MILKING PARLOUR

Milk's journey from cow to cornflakes starts in the farm's milking parlour. Each cow is usually milked twice a day. Automatic milking machines have four suction cups attached to hoses, which are placed over the cow's four teats. A pump sucks air from the hoses in a steady rhythmic pattern that mimics a calf suckling, making the milk spurt from the udder.

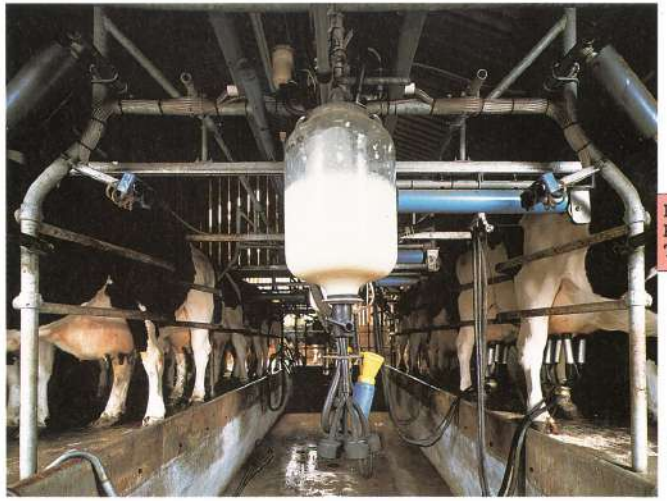
It then passes through a volume-measuring meter and into a cooled storage tank. Refrigerated tankers visit the farm every day and transport the raw milk to the local dairy for processing.



The Bare Bones

Cows produce milk only after giving birth to a calf, just as humans do after having a baby. A dairy cow has her first calf at the age of about two, after which she produces milk for around 10 months. From then on she has a calf roughly once a year, to keep the milk-producing cycle going. An average dairy cow goes through this cycle three or four times, but a good 'milker' may continue for up to 10 cycles.

To cover the cost of her grazing, feed, care and upkeep, a dairy cow must produce about 6000 litres of milk a year.



Fat standards

A dairy produces various types of milk with different fat contents. Part of each milk delivery is passed through a cream separator – a machine rather like a spin drier – to produce skimmed milk and cream.

Some of the output is held in separate storage tanks and is used to adjust the fat content of the rest of the delivery, which is continuously tested as it is processed. If the fat content drops below the required level, cream is added to it. If the fat content rises, skimmed milk is mixed in instead. The rest of the separated cream and skimmed milk is put directly into cartons or bottles.

Beating bacteria

Once the milk has the desired fat content, the next stage it goes through is pasteurization.

Untreated milk goes off because it contains natural bacteria. They feed on the lactose, turning it into sour-tasting lactic acid.

Pasteurizing milk means heating it to about 72°C for 15 seconds, and then cooling it quickly to less than 5°C. This kills the bacteria and stops the milk going sour.

DATA FOR DOGS

TOO MUCH FAT IS BAD

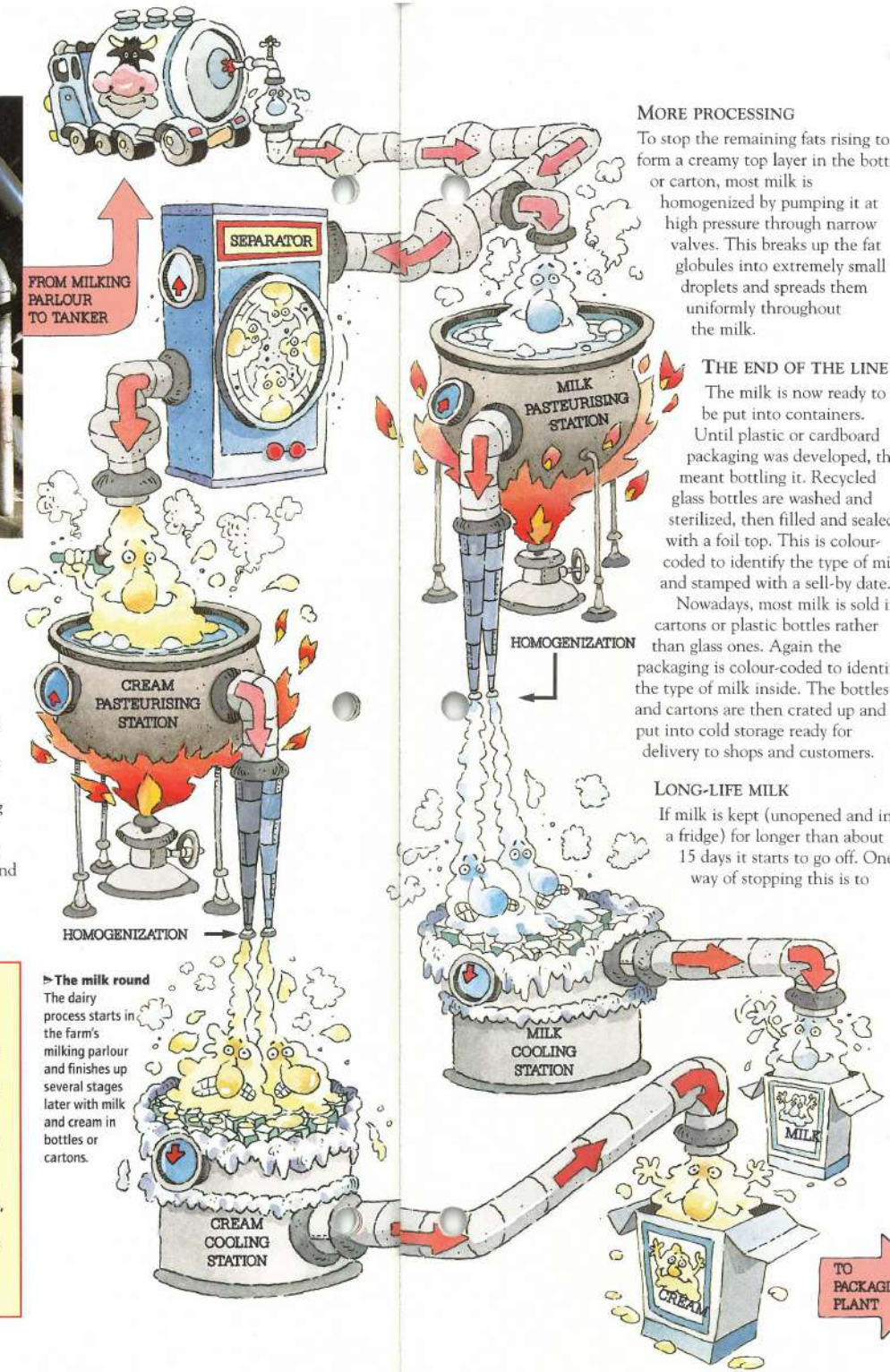
Nowadays, most people know that too much animal fat – including the fats in milk – can cause heart problems and other health risks. So the dairy industry now produces a range of milk products containing less fat.

Milk is about 87% water and contains up to 4% fat in the form of creamy droplets spread through the milk. As they are lighter than water, they float to the top if the milk is left to stand. This layer can be skimmed off as cream, leaving skimmed milk behind.

WHAT'S GOOD IN MILK

Apart from fat, milk also contains about 5% sugar (called lactose). This is its main energy-giving ingredient. The rest of the mixture is made up of proteins (about 4%), minerals including calcium (good for bones and teeth), and several vitamins.

Skimmed milk lacks certain valuable ingredients, especially vitamins A and D, because these are concentrated in the cream. To make up for this, vitamins are added to the milk at a later stage maintaining its food value.



The milk round The dairy process starts in the farm's milking parlour and finishes up several stages later with milk and cream in bottles or cartons.

More processing

To stop the remaining fats rising to form a creamy top layer in the bottle or carton, most milk is homogenized by pumping it at high pressure through narrow valves. This breaks up the fat globules into extremely small droplets and spreads them uniformly throughout the milk.

The end of the line

The milk is now ready to be put into containers. Until plastic or cardboard packaging was developed, this meant bottling it. Recycled glass bottles are washed and sterilized, then filled and sealed with a foil top. This is colour-coded to identify the type of milk and stamped with a sell-by date.

Nowadays, most milk is sold in cartons or plastic bottles rather than glass ones. Again the packaging is colour-coded to identify the type of milk inside. The bottles and cartons are then crated up and put into cold storage ready for delivery to shops and customers.

Long-life milk

If milk is kept (unopened and in a fridge) for longer than about 15 days it starts to go off. One way of stopping this is to sterilize it by pumping steam into the milk for a few seconds. It is then cooled and put into sterile containers. The process is known as ultra-heat treatment (UHT) and produces so-called 'long-life' milk. Unopened, UHT keeps for about three months and doesn't need refrigeration.

Milk in a can

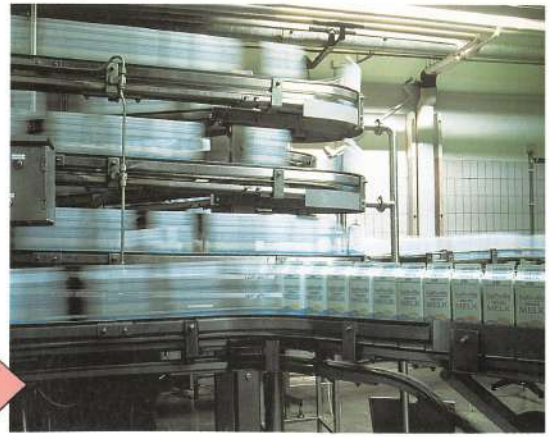
Milk sold in cans is processed by passing treated milk through a low-pressure vacuum chamber. Here it

BRIGHT SPARKS

Louis Pasteur (1822-1895) was a brilliant French scientist. His experiments in microbiology showed that food and drink did not 'go off' in sterile conditions, but would do so if exposed to air-borne micro-organisms.

This proved that germs caused diseases instead of being produced by them, as was believed at the time. He therefore proposed the idea of heat treatment (pasteurization) to kill bacteria in wine and beer, and then modified the process for treating milk.

The makers of bottled sterilized milk clearly thought their product vastly superior to the tinned variety.



A modern bottling plant can containerize enough milk in one second to supply the needs of an average family for 10 years.

▷ Astronauts like ice cream too, so scientists created a freeze-dried version that took milk into the space age.

boils at a lower temperature than normal and some of the water evaporates, leaving it thicker and creamier.

Evaporated milk is canned and then heat-sterilized. Condensed milk is unsterilized evaporated milk with sugar added to preserve it. Dried milk is made by spraying evaporated milk into a very hot drying chamber. The resulting dried milk falls to the bottom as a fine powder. Kept in air-tight packaging, it lasts for up to 18 months.

DID YOU KNOW?

FAT LEVELS IN MILK AND CREAM

The amount of fat in milk and cream is usually standardized by law. The exact amounts vary from country to country, but these are the average fat contents for the commonest products:

Low-fat skimmed milk 0.5-2%
Medium-fat semi-skimmed milk 2-3%
Whole or full-fat cream milk 3-4%
Half cream about 12%
Single cream 18% or more
Whipping cream 35-40%
Double cream about 50%
Clotted cream 55-60%

The USA is the world's biggest milk producer, relieving its huge dairy herds of around 70 million tonnes of milk every year.

SEE ALSO
Bacteria, Bottles, Cans, Cheesemaking, Packaging

Daisy-wheel

In 1961, the computer giant IBM introduced a tangle-free typing system – the golf-ball. This successful system was patented for use only on their machines. The other typewriter makers were left with their keys crossed, hoping for a solution! And it arrived in the late 1970s in the shape of the daisy-wheel.

Pressed petals

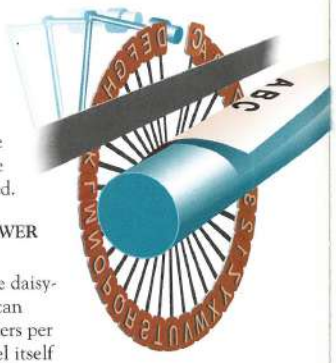
The daisy-wheel typewriter differs from the traditional typewriter because, instead of having a row of levers (type bars), its printing mechanism consists of a plastic disc with petal-like spokes. Each 'petal' has characters embossed on its tip. When the typist presses a key, a motor spins the daisy-wheel around to the required character. The chosen 'petal' is then hammered against the type ribbon and the letter is printed.

▲ This daisy-wheel has capital letter and lower case petals. Some models have both on one petal.

Flower power

In electronic typewriters the daisy-wheel system can print 20 characters per second. The wheel itself can contain up to 190 characters which allows for typing in 15 separate languages. The system also offers 26 different styles of type which are changed by simply swapping the wheel.

The system is still used today, but attempts to use it in computer printers have not been so successful. The daisy-wheel may be multi-lingual, but it can't draw.



▲ Heavy petal! The motorized hammer punches a letter on to the inky ribbon and it appears on the paper.

SEE ALSO
Printers
Typewriters
Word processors

Ears

During a walk in a wood, a stream babbles, birds twitter and then a jet plane screams over the tree tops. Sounds like these tell you a vast amount about your surroundings.

You hear what is going on in the world around you through your ears. They are your sensitive living microphones which detect sound waves in the air.

The outer ear

The first part of an ear's job is to collect sound waves. The cone-shaped ear flap on the side of the head funnels sound waves into a dark tunnel called the ear canal. It ends at the eardrum, a tightly stretched sheet of skin about as big as your little finger nail. As incoming sound waves bounce off it, the eardrum vibrates.

The middle ear

Beyond the eardrum are the three smallest bones in your body called the hammer, anvil and stirrup. They are hinged to transmit vibrations in the eardrum across the middle ear.

The base of the stirrup lies against the oval window in the wall of the snail-shaped cochlea. As it plunges backwards and forwards, it makes waves in the fluid inside.

PARTS OF THE EAR

The Bare Bones

Sound waves are caused by vibrations. When you bang a piece of wood with a hammer or pluck a guitar string, it starts to shake rapidly (to vibrate). Every vibration pushes out invisible rings of high and low air pressure, like ripples on a pond. It is these variations in air pressure that your ears pick up.

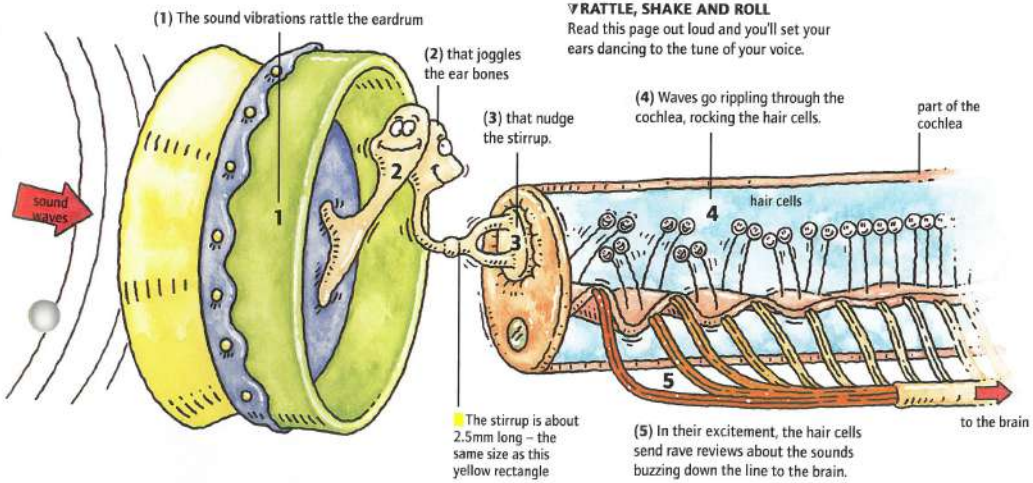
The pitch of a sound (how high or low it is) depends on how far apart the ripples are – the closer together they are, the higher the pitch. Volume relates to ripple size – the bigger the ripple is, the louder it sounds.

The inner ear

Inside the cochlea, the ripples in the fluid set hundreds of hair cells rocking at their bases. Their movement fires off thousands of impulses per second in the auditory nerve that carries the signals to the hearing centre of the brain. There they are decoded as the sounds you are listening to.

Looking after your ears

The lining at the outer end of the ear canal produces earwax which traps dirt. Sometimes, earwax collects in the canal and has to be removed by a doctor. Never use a pointed object to dig earwax out as you can easily damage your eardrum.



The stirrup is about 2.5mm long – the same size as this yellow rectangle

RATTLE, SHAKE AND ROLL

Read this page out loud and you'll set your ears dancing to the tune of your voice.

All ears

Only animals with backbones (vertebrates) have true ears and ear flaps are exclusive to mammals. Spineless animals (invertebrates) like insects can detect sounds without having complicated ears.

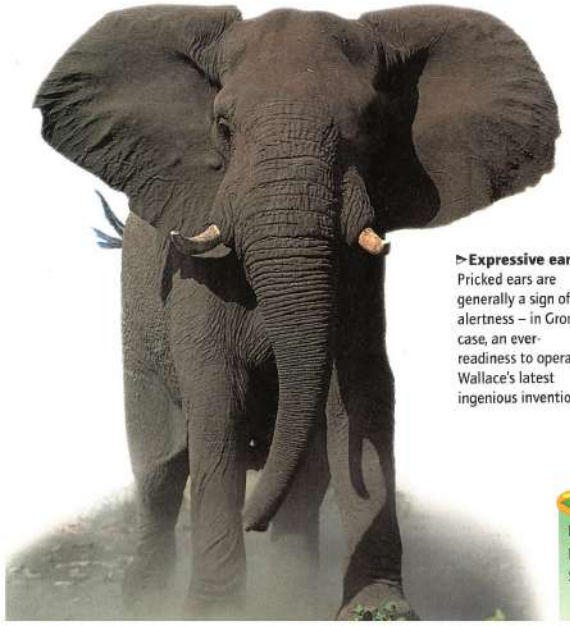
On bended knee
If you wanted to whisper in a cricket's 'ear', you'd have to put your mouth close to a knee on one of its front legs.

Watch out!
Animals often use their ears to signal what sort of mood they're in. When angry, a tiger twists its ears forward, flashing white spots on the back to warn off would-be attackers before it comes to a dangerous tooth-and-claw fight.

Small flaps
Compared with other animals, human ears are pretty tame – just small, stationary flaps lying more or less flat against the head (naming no names above). They are useful as hooks on which to hang a pair of glasses or attractive earrings, fine for catching whispers but hopeless for scaring off your enemies.

Biggest ears
When comparing ears to body size, bats win the largest-ears-of-all prize. The long-eared bat's ears are nearly as long as its body. Big ears help it find its way around using echoes.

Air conditioning
African elephants have gigantic ear flaps that they wave around to help cool themselves off. The biggest are 1.8m across, large enough to cover a single bed. When challenged, an elephant gets hot and bothered, so it spreads its ears out to the side to stay cool – and makes itself look more formidable at the same time.



Cool, sharp hearing
Fennec foxes have very big ears perfectly designed for life in the Sahara desert. Lots of veins run close to the surface of their ears losing heat from the blood. This helps the foxes keep their cool while they are lying low during the day. Huge ears also give them supersensitive hearing when hunting at night.

Expressive ears
Pricked ears are generally a sign of alertness – in Gromit's case, an ever-readiness to operate Wallace's latest ingenious invention.

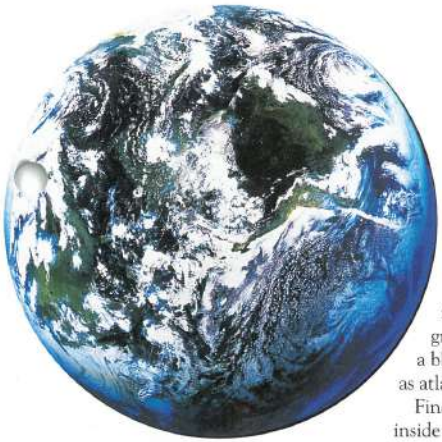
Flapless ears
For the sake of streamlining, marine mammals, such as whales, dolphins and true seals have dispensed with ear flaps altogether. Seals have very narrow ear canals that they can close during a dive to stop water getting in.

DID YOU KNOW?

POP GO YOUR EARS
Sometimes you get a funny feeling in your ears – when you go up or down in a fast lift for example. This is because the air pressure is changing quickly, and the pressures in your outer and middle ear are unequal.

Then suddenly you feel a popping sensation, especially if you open your mouth. This happens when a narrow tube between your middle ear and throat opens so air can escape from or enter the middle ear to balance pressure on each side of the ear drum.

SEE ALSO
Balance
Hearing
Sound



Earth

If you were lucky enough to be a crew member on a space shuttle flight, you could look down on the Earth and see that it is covered in a patchwork of green land and blue oceans under a blanket of fluffy white clouds, just as atlas and satellite pictures show.

Finding out what the Earth is like inside takes a little more detective work. The closest anyone could come to looking straight into the centre would be to peer down the throat of an active volcano into a glowing lake of red-hot molten rock.

In such as restless place, it is easy to imagine that the Earth is made up of a fragile rocky shell round a cauldron of fiery liquid. But evidence from studying volcanoes and earthquakes points to a more layered structure of solid and molten rocks.

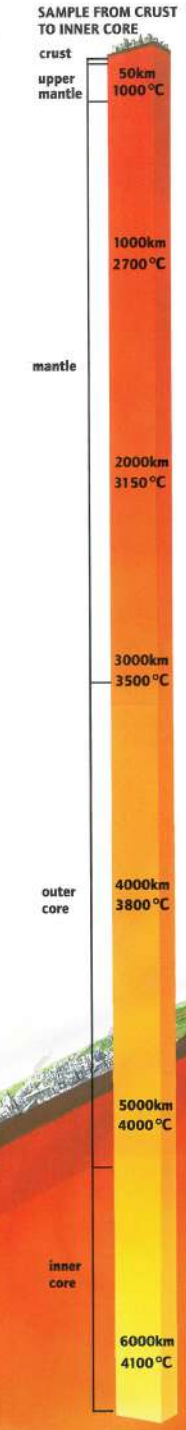
Earth myths
Before exploration and science, people made up myths to explain the shape of the Earth and its relationship to the sun, moon and stars.

The primitive idea of a cosmic egg hatching into earth and sky arose in many parts of the world.

Hindus saw the Earth as resting on the back of four elephants standing on top of a turtle wrapped in a snake.

The ancient Egyptians showed the sky goddess Nut bending over a round Earth held up by her father Shu, the air god.

The natural fireworks of a volcanic eruption give a violent insight into what the inside of the Earth is made of.



A ROCKY CRUST

The Earth is covered with a crumpled, rocky shell called the crust. The land you are standing on is part of the thick continental crust.

Rocks in the continents are not as heavy as those in the layer immediately below the crust (called the mantle). They were probably formed quite early in the life of the planet from molten material that floated to the surface, like scum on the top of a pan of simmering jam.

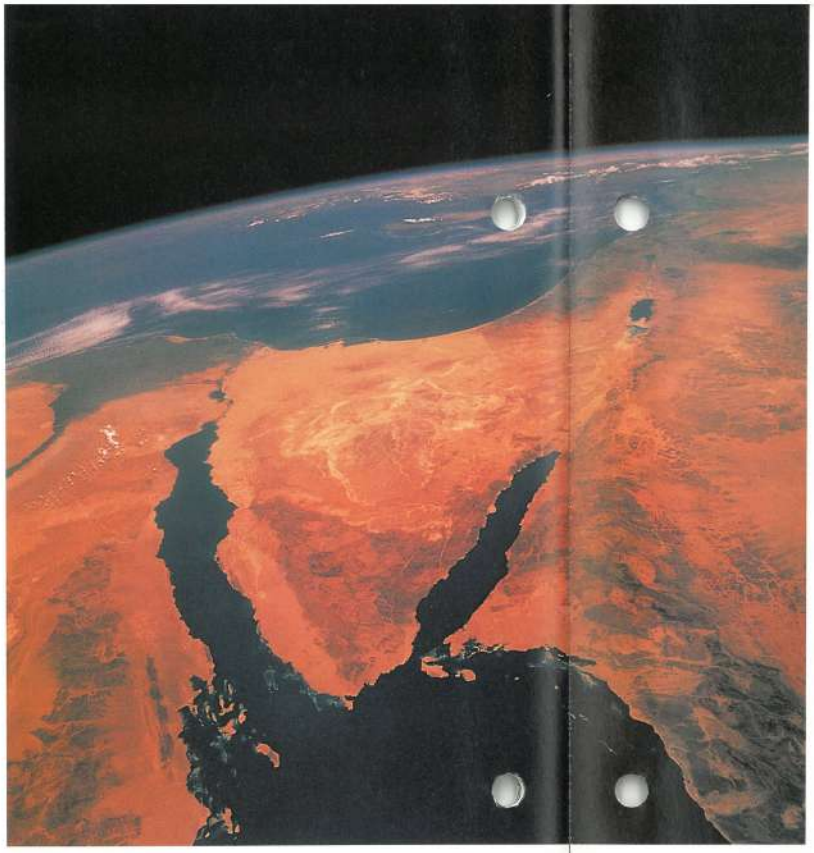
The Earth has cooled since then, but the continents still float around, rather like ice on the polar seas. Just as an iceberg descends far below the surface, a high mountain range has deep roots. As the mountain tops are worn away and they become lighter, the land bobs a bit higher.

Under the oceans, the oceanic crust is much thinner and younger than the continental crust. It is still being formed continuously as molten rock oozes up from the mantle through cracks in the ocean floor along mid-oceanic ridges.

THE CREEPING MANTLE

Although the rock in the mantle is very hot, it stays solid because it is under immense pressure from the Earth's interior. Being solid doesn't necessarily mean hard and rigid. A lump of clay is solid, but you can mould it in your hands. If you shape the lump into a ball and leave it on a table, it gradually sags as the clay particles creep past each other under the force of gravity.

Mantle rock behaves in much the same way. The intense heat does not melt the rock, but it softens it so that it creeps like clay. The heat also creates currents that circulate in the mantle. The hot mantle rock rises towards the cool, hard crust, where it glides along and sinks again as it cools. The mantle rock is moving very slowly, at only a few centimetres a year. But it is on the move.



⚠ The relentless creep of the mantle pulls the continental land masses apart, creating great scars, like the Red Sea. It is widening all the time, so Africa and Asia are separating at the rate of 2cm each year.

⚠ Harbours used by the Vikings 1000 years ago are now 10 metres above sea level. During the last Ice Age, Northern Europe was weighed down by a thick ice sheet. When the ice melted, the crust started to rise and is still rising at about 1cm a year.

RISING MAGMA

As it rises the mantle rock comes under less and less pressure, so bits of it start to melt. The molten mantle rock is called magma. It is still under immense pressure and gets squeezed up towards the surface.

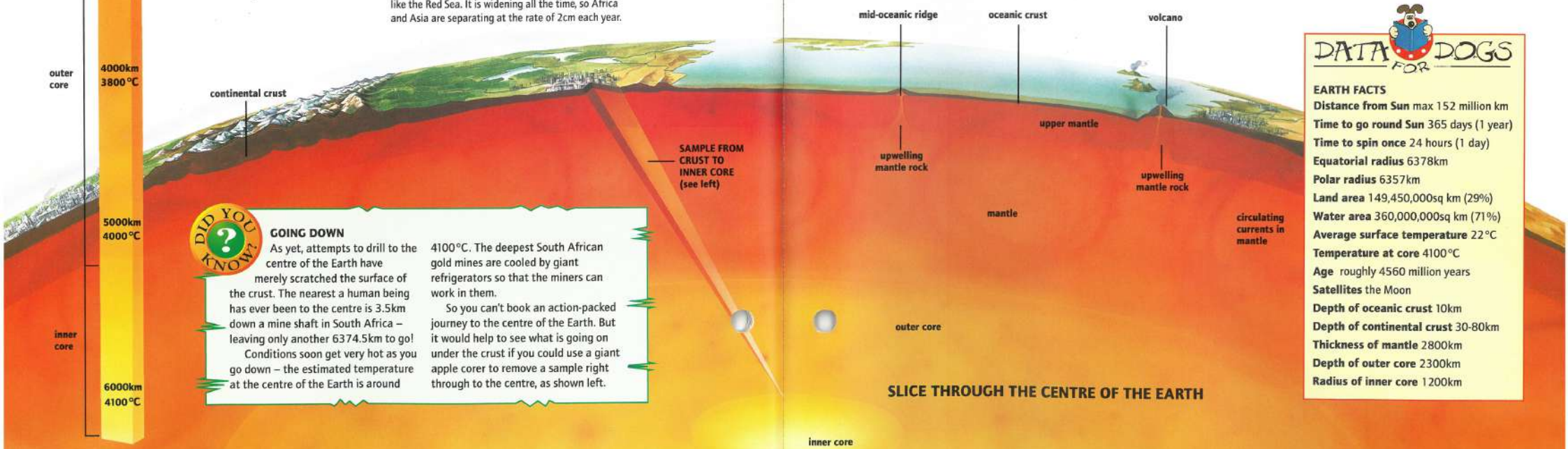
As some minerals melt before others, the magma contains a slightly different mix of chemicals from the solid mantle rock. This makes it less dense than the surrounding mantle, so it tends to lie on top in great blister-like magma chambers. Eventually the blisters burst through cracks in the crust as volcanic eruptions and magma cascades or flows on to the surface of the planet.

THE HEART OF THE MATTER

As the mantle rock moves, it drags the crust with it. The rocks in the crust are cool and too brittle to be stretched far. Eventually the rock snaps, which releases shock (seismic) waves that are felt as an earthquake.

The shock waves travel easily through solid rock but are slowed down or stopped by liquid rock. Some waves pass straight through the Earth and can be detected on the opposite side of the globe. By timing them, scientists now know that the Earth has a solid inner core surrounded by a liquid outer core.

The Earth is also much heavier than expected if it was filled with mantle-type rock alone, so the core must be very heavy indeed. It's likely that the inner and outer cores are made of a similar mixture of iron and nickel found in meteorites – bits of cosmic debris formed at the same time as the Earth.



SLICE THROUGH THE CENTRE OF THE EARTH

DID YOU KNOW?

GOING DOWN

As yet, attempts to drill to the centre of the Earth have merely scratched the surface of the crust. The nearest a human being has ever been to the centre is 3.5km down a mine shaft in South Africa – leaving only another 6374.5km to go!

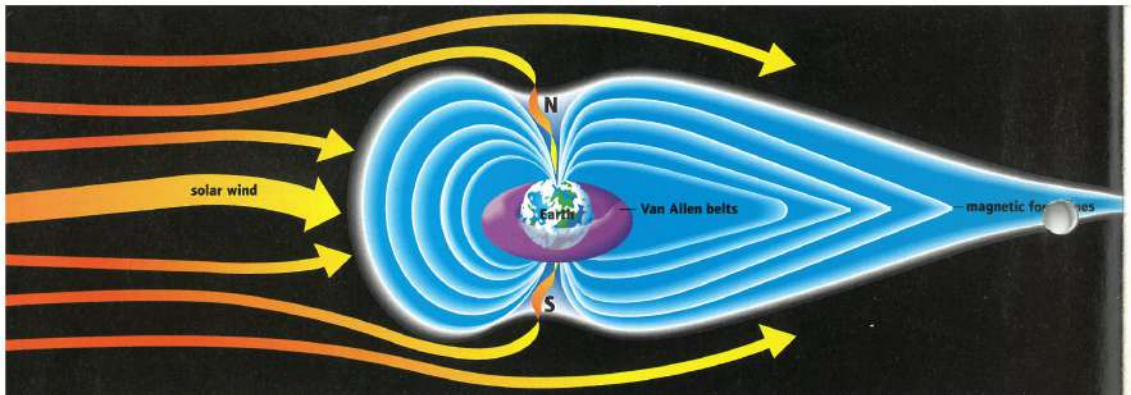
Conditions soon get very hot as you go down – the estimated temperature at the centre of the Earth is around 4100°C. The deepest South African gold mines are cooled by giant refrigerators so that the miners can work in them.

So you can't book an action-packed journey to the centre of the Earth. But it would help to see what is going on under the crust if you could use a giant apple corer to remove a sample right through to the centre, as shown left.

DATA FOR DOGS

EARTH FACTS

Distance from Sun max 152 million km
Time to go round Sun 365 days (1 year)
Time to spin once 24 hours (1 day)
Equatorial radius 6378km
Polar radius 6357km
Land area 149,450,000sq km (29%)
Water area 360,000,000sq km (71%)
Average surface temperature 22°C
Temperature at core 4100°C
Age roughly 4560 million years
Satellites the Moon
Depth of oceanic crust 10km
Depth of continental crust 30-80km
Thickness of mantle 2800km
Depth of outer core 2300km
Radius of inner core 1200km



The Earth's magnetic field serves as a shield to stop dangerous cosmic particles carried on the solar wind pelting the surface of the planet.

The spectacular northern and southern lights – aurora borealis and aurora australis – in the Arctic and Antarctic skies are set off by cosmic particles drawn down into the atmosphere at the magnetic poles.

Magnetic attraction

2

The iron in the inner and outer cores is the source of the Earth's magnetism. The planet behaves like a giant bar magnet, with north and south poles that lie near the geographic North and South poles.

The spinning of the Earth stirs up whirlpool movements in the liquid outer core which make it behave like a dynamo generating an electric current. It is this current that induces magnetism in the solid inner core.

Invisible magnetic force lines radiating into and away from the magnet's poles wrap the Earth in a force field, leaving the Arctic and Antarctic regions exposed. Between 3000 and 16000km from the Earth, the magnetic field forms doughnut shaped rings called the Van Allen belts.

The magnetic field protects life on Earth from being bombarded by harmful cosmic rays and electrically charged particles swept from the Sun on the solar wind. The solar wind presses the force field in on the sunward side and blows it out into a long tail on the far side.

SEE ALSO

Atmosphere, Continental drift, Day and night, Earthquakes, Gravity, Magnetism, Moon, Seasons, Solar system, Sun, Universe, Van Allen belts, Volcanoes

TECHNO Talk

1

HIDE AND SEEK

More and more uses are being found for the world's most accurate navigation system. The Global Positioning System (GPS) uses 21 satellites orbiting the Earth to locate any point on the planet. A hand-held receiver (below) measures how long it takes for signals from three of the satellites to reach the receiver. The receiver de-codes the signals to give directions and distances - exact to within only one metre. It can even give an estimated time of arrival. Climbers and hill walkers also use the GPS so that they don't get lost in unfamiliar country. Fishing fleets use it to find good hunting grounds and car rental companies for keeping track of their vehicles.

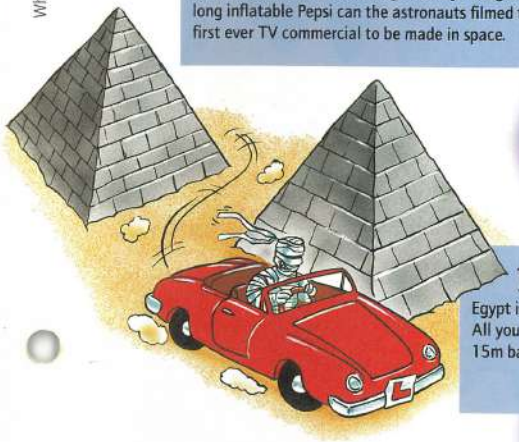
What was Aardman Animation's first production?

STOP, LOOK, SMELL

Scientists in Kuwait are using artificial wolf urine to stop camels wandering on to busy roads. When the camels get near a road that has been treated with the fake wolf urine the smell makes them think it's the territory of a dangerous animal and they stay away from the road. The idea was discovered in Norway when experts were trying to find a way of stopping deer holding up the traffic.

DID YOU KNOW?

Russian astronauts recently helped Pepsi Cola break new ground in the advertising industry. Using a 1.2m long inflatable Pepsi can the astronauts filmed the first ever TV commercial to be made in space.



DID YOU KNOW?

Egypt is the place to go for the world's easiest driving test. All you have to do to get a pass is drive the car 15m forward, 15m backward and then park between two traffic cones.

At what temperature on the Kelvin scale does water boil?

Answers to all the questions appear in Techno Talk Part 2

SHOE SHOCK

What have a jumbo jet, a woodpecker and a pair of trainers got in common? They've all got shock absorption systems. A jumbo jet has springy pistons in the undercarriage to make landing more comfortable. A woodpecker has springy bones that protect its brain while it is whacking its head against a tree. Trainers have special spongy plastic soles with air-filled bubbles in them to absorb the shock of running on hard ground.

The shock absorbers in trainers protect an athlete's limbs and joints from the effects of pounding against hard ground. Most quality jogging, tennis and basketball shoes now contain shock absorbers.

Different shoe manufacturers produce different shock absorbers. Most have a cushioned mid-sole and some contain a water-based, gas-filled jelly that is injected into the sole. The super-strong jelly gives extra shock absorption under the heel and can been seen in many types of trainers thanks to a plastic 'window' in the sole.

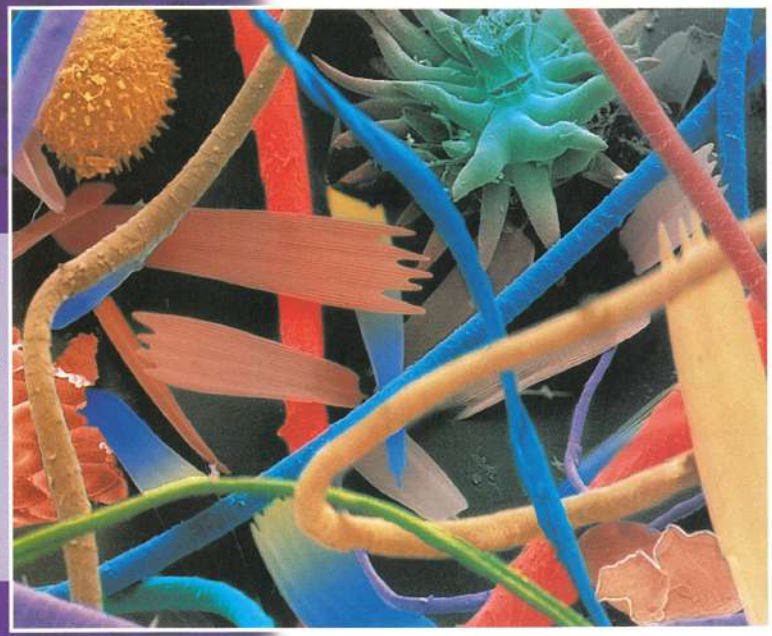
DID YOU KNOW?

Parents may complain about the price of trainers 'nowadays' but their grumbles do not have the backing of the law as they did in 15th-century England. Back then it was pike not Nike shoes that were all the rage. A law decreed that anyone earning less than £40 a year (about £16,000 today) was not allowed to wear the long, pointy-toed pikes.

ZOOMING IN

Scientists use a scanning electron microscope for greatly magnifying things that can't be seen with the naked eye – bacteria and blood cells for example. But these microscopes can also give us a revealing view of everyday objects.

Can you guess what this is? Clue: If it's a problem, housework helps



In which country are the world's biggest cables?

WALK ON WATER

The mystery of the lizard that walks on water has been solved. For years scientists have wondered how the basilisk lizard manages to run across water.

When frightened the basilisk stands up on its hind legs and scuttles across the surface of the ponds and rivers in its rainforest homeland. Using special film footage biologists have discovered exactly how it performs this amazing feat.

As the basilisk runs across the water it swings each hind foot through the air and then slaps it down. As the foot pushes downwards it traps a tiny pocket of air and floats.

The study also revealed that the basilisk – or Jesus Christ lizard as it is called in its native Central America – doesn't just run to get away from predators. It also runs on water because it likes to!

SHAPING UP

Moving clockwise around the shape, join the groups of letters then divide them so they spell out a phrase. On the right is an example. Answer: *A Grand Day Out*

Now try the one on the left. Clue: a dirty job for Wallace & Gromit.

PARTY TRICK

A girl who lived in northern Alaska wanted to go to an all-night party. Her parents said she could provided she was back by sunrise. When she came home she looked older and had longer hair. Her parents were not surprised by her changed looks. Do you know why?

WORD SEARCH

Hidden in this grid are five words (running vertically and horizontally) linked with abrasives. Of course, if you haven't read the article you won't know what the words are. Why not time yourself and see how long it takes to find them?

M	O	S	H	G	E	S	F	M
O	Z	T	I	N	C	H	I	S
H	G	E	M	S	T	O	N	E
S	E	H	S	T	H	R	L	A
E	K	M	T	O	F	T	I	S
A	F	I	L	I	N	G	N	H
S	L	T	O	N	L	I	Q	O
T	O	Q	E	X	F	L	U	R
O	U	Q	U	A	R	T	Z	E

RACE PLACES

There's mass confusion at the Wallaby Road Olympics. After the last race the results were not written down. Luckily the one person watching could remember where some of the runners finished. He said "Wallace was not third or first and Gromit was two places ahead of Preston. Oh, and Wendolene was two places behind Wallace." Can you work out the finishing order?

How did the daisy-wheel get its name?

What's Wallace's line?

It is one of the lines used to divide the Earth's biogeographical regions or 'biomes'. When planet Earth developed, certain groups of animals became isolated as natural barriers like oceans and deserts took shape. Animals evolved differently from those in other parts of the world. Wallace's line separates the ones that evolved in southern Asia, such as tigers, elephants and orang-utans, from those that evolved in Australia, such as kangaroos, koalas and the duck-billed platypus. It's named after the naturalist Alfred Wallace (1823-1913) – no relation to our Wallace.

How are fizzy drinks made fizzy?

Fizzy drinks such as lemonade and cola are carbonated – they have carbon dioxide gas (CO_2) pumped into them when they are bottled.

Under pressure carbon dioxide is absorbed by the liquid. But when the pressure in the bottle is reduced – when the top is taken off – the CO_2 is released from the liquid and forms bubbles.

Open a can or bottle and the pressure changes dramatically as the CO_2 is released with a rapid woosh. By the way it's also the carbon dioxide in the drink that makes us burp!

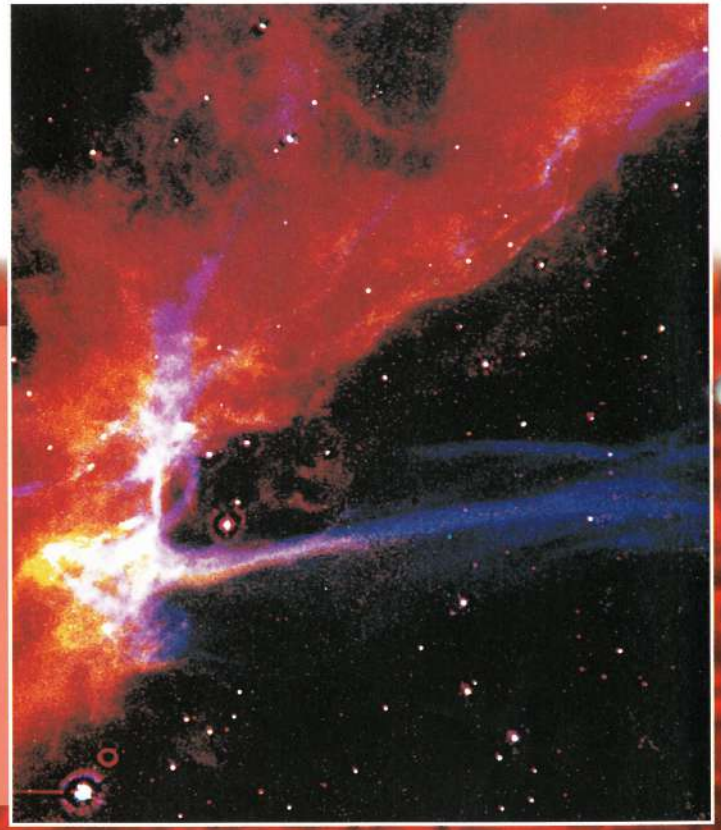
What percentage of milk is made up of water?

What's a Supernova?

A supernova is a massive explosion that shines a thousand million times brighter than our Sun.

The flash, that can often be seen for months, is caused when a star gets old and begins to break up. The substance of the dying star is blown into an expanding gas. This causes a huge explosion which mixes with the gases in space and makes an even bigger bang.

Many of the particles from supernovas fall through the Earth's atmosphere. It is believed that all the Earth's gold is actually supernova litter.



Is the planet Earth getting lighter?

At the moment the Earth breaks the scales at just under 6000 billion, billion tonnes in weight. Many people think that it is getting lighter because we burn things like wood, coal and oil and turn it into smoke. Although millions of tonnes of stuff is burnt every year much of the gas produced

remains in the atmosphere and maintains the Earth's mass. In fact, huge amounts of dust also fall to the Earth from space. So although you do not notice it, this probably goes a small way to increasing the weight of the Earth and over the years it may be getting heavier!